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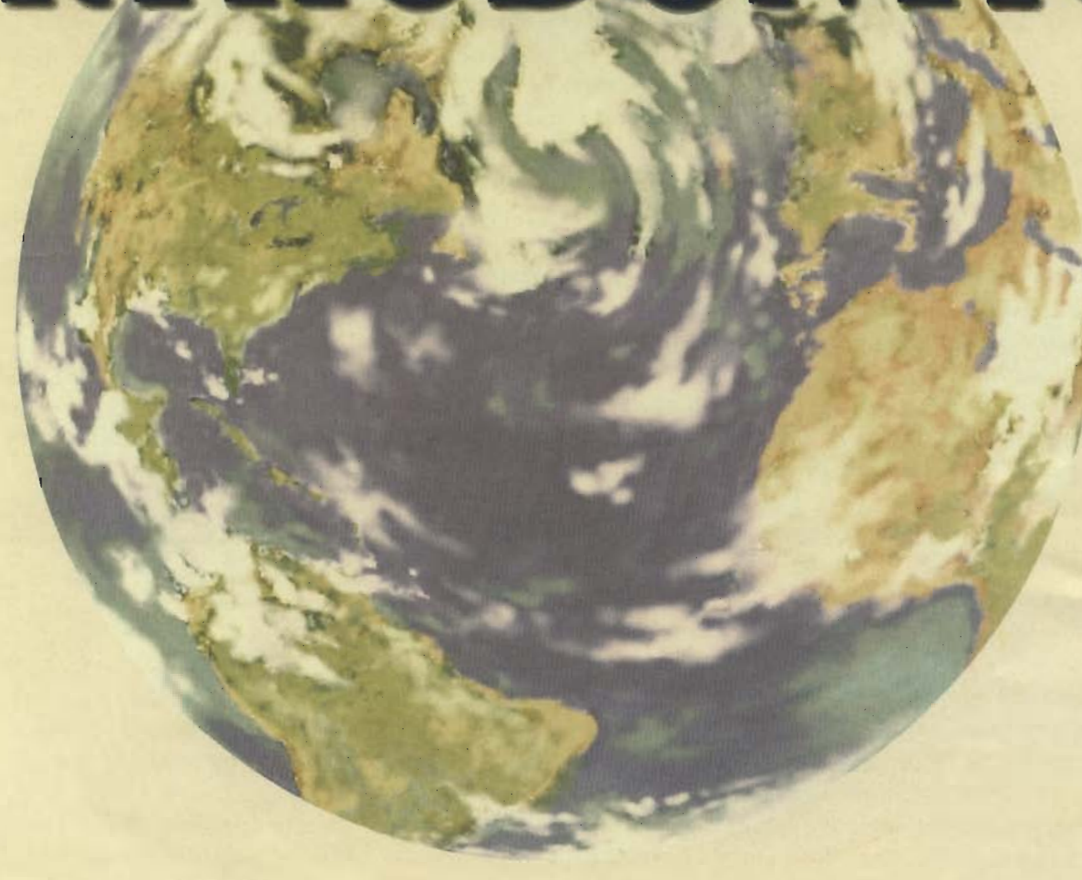

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Rapid Orthodontic Decrowding with Alveolar Augmentation: Case Report

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This article demonstrates a new orthodontic method that provides shortened treatment times and concomitant periodontal alveolar augmentation. A female patient, 27 years of age, with a Class I, moderately crowded malocclusion, elected to undergo this new treatment option, due to the estimated reduction in treatment time. During the week following bracketing and wire activation, labial and lingual full-thickness flaps were reflected in the maxillary and mandibular arches. The exposed cortical layer of bone over the roots of the teeth designated for the major orthodontic movements was then selectively decorticated. Prior to the primary flap closure, a bone grafting/augmentation procedure was performed over the partially decorticated bone. Following the periodontal plastic surgery, the orthodontic adjustments were performed approximately every 2 weeks. No excessive forces were used. The total orthodontic treatment, from bracketing to debracketing, required exactly 6 months, with 12 orthodontic adjustments. The authors theorize that the rapid orthodontic decrowding and minimal apical root resorption are attributable to increased regional bone turnover (the regional acceleratory phenomenon) and the associated osteopenia (ie, calcium depletion and diminished bone density) that was precipitated by selective decortication. World J Orthod 2003;4:197–205

Rapid orthodontic tooth movement and reduced treatment times are now readily attainable without compromising treatment results. Wilcko et al have demonstrated rapid orthodontic tooth movement following limited selective labial and lingual alveolar decortication.[1] The inclusion of a grafting procedure makes it possible to simultaneously augment and reshape the supporting alveolar bone.[1] The combination of corticotomy-facilitated orthodontic treatment and periodontal alveolar augmentation has been named the Accelerated Osteogenic Orthodontics (AOO) procedure. (The AOO appliances and method of the Accelerated Osteogenic Orthodontics procedure are patented by Wilckodontics, Erie, PA, USA.)

It has been demonstrated that the same treatment results achieved with nonextraction orthodontic therapy without corticotomy can be attained with the AOO procedure, but in one-third the treatment time.[2] The active orthodontic treatment of moderately crowded arches in both children and adults can be completed in 4 to 6 months; treatment results suggest that the need for extractions may be reduced. Pre-existing alveolar fenestrations over root prominences can be eliminated, thus reducing the probability of bony dehiscence formation. Additional lip support can also be achieved with the alveolar augmentation.

CORTICOTOMIES IN ORTHODONTIC TREATMENT

Surgical alveolar corticotomies have been used in correction of malocclusions for over 100 years. L. C.

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Fig 1 *(Left)* Example of circumscribing corticotomy cuts shown on the labial aspects of the six mandibular anterior teeth.

Fig 2 *(Right)* Example of selective decorticating shown on the labial aspects of the mandibular anterior teeth and premolars, where circumscribing cuts were used on the left side and small perforations were used on the right side.

Bryan discussed one such surgical procedure before the American Dental Society of Europe in 1892.[3] In 1959, Heinrick Köle reported on a combined interradicular corticotomy/supra-apical osteotomy technique for rapid tooth movement.[4] Köle's technique utilized a 1-stage surgery, indicating that both the labial and lingual aspects were treated at the same appointment. Köle felt that it was the continuity of the harder cortical layer of bone that presented the greatest resistance to tooth movement. He speculated that this resistance to tooth movement could be overcome by creating "blocks of bone" that were connected to each other by medullary bone only, and that these "blocks of bone" could be moved by using the crowns of the teeth as the handles. He attributed the rapid tooth movement that was achieved to the decreased resistance offered by the softer medullary bone. Düker, in 1975, successfully duplicated Köle's technique in a report of alveolar corticotomies, using beagle dogs.[5] Generson et al, in 1978, reported successful results utilizing a 1-stage corticotomy-only technique for rapid tooth movement.[6] Generson's revision included replacing Köle's supra-apical osteotomy with a corticotomy. Using only labial and lingual corticotomy cuts to circumscribe the roots of the teeth, Anholm et al in 1986,[7] Gantes et al in 1990,[8] and Suya in 1991[9] also reported rapid tooth movement and reduced treatment times. All three articles reported no clinically noticeable adverse periodontal effects resulting from the corticotomy-facilitated orthodontic treatment. Köle's speculation in 1959 concerning movement of "blocks of bone" as the principle mechanism to explain rapid tooth movement has prevailed in subsequent publications.

In 2001, Wilcko et al reported on a revised corticotomy-facilitated orthodontic technique that included periodontal alveolar augmentation; this was referred to as the AOO procedure. Hajji, in master's thesis research, tested the claim of rapid tooth movement and advantages of alveolar augmentation by comparing AOO with nonsurgical orthodontic therapies.[2] She evaluated mandibular arch decrowding using three treatment modalities: conventional extraction, conventional nonextraction, and nonextraction corticotomy-facilitated orthodontics. Treatment effects on seven cephalometric and five study cast variables were appraised in homogeneous pretreatment groups; no differences in posttreatment results were found between the two nonextraction groups. Remarkably, active orthodontic treatment time in the corticotomy group was 6.1 months, compared to 18.7 (conventional nonextraction) and 26.6 (conventional extraction) months.

In an attempt to gain a better understanding of the mode of tooth movement following corticotomy surgery, the 1-stage corticotomy-facilitated orthodontic technique was duplicated. An example of the circumscribing corticotomy cuts that were used is shown in a mandibular anterior area of one of the test patients (Fig 1). The 1-stage corticotomy-facilitated orthodontic technique resulted in rapid tooth movement and reduced treatment times, as had previously been reported.[6–9] Pre- and posttreatment radiographic analyses, including surface computerized tomography (CT) scans, did not lend visual support to the "bony block" movement concept. Instead, the findings appeared to be more suggestive of a demineralization/remineralization phenomenon. To test this possibility, the circumscribing cortical cuts were eliminated and replaced with small round cortical perforations. This eliminated the possibility of "bony block" movement. The 1-stage corticotomy-facilitated orthodontics utilizing small round cortical perforations resulted in the same rapid tooth movement and reduced treatment times. Figure 2 shows the mandibular arch in a patient in whom circumscribing corticotomy cuts were used on the left side and small round cortical perforations were used on the right side. There was no detectable difference in the rate and ease of movement between the right and left sides of the arches, and the total treatment time for this patient was 4 months 3 weeks, with eight orthodontic adjustments. If the rapid tooth

Fig 3 Pretreatment intraoral photographs of the female patient, 27 years of age, presented in this case report. **(a)** Anterior and **(b)** left lateral views.

movement in corticotomy-facilitated orthodontics could not be attributed to "bony block" movement, what phenomenon could more adequately explain what was happening?

Hajji's corticotomy sample included subjects with cortical perforations and no labial or lingual cuts circumscribing the roots. Rapid tooth movement was also achieved using only corticotomy perforations. This finding suggested that rapid tooth movement was associated with increased regional bone turnover (regional acceleratory phenomenon) and not "bony block" movement. Although the influence of corticotomy on tooth movement is unknown and mechanisms of tooth movement following corticotomy have not been investigated, the authors believe that the cancellous portion of alveolar bone is induced into a more pliable, transient state called osteopenia, which, in turn, facilitates rapid tooth movement. Osteopenia is characterized by diminished bone density but not bone volume, a condition that should facilitate rapid tooth movement.

CASE REPORT

A female, 27 years of age, had a Class I, moderately crowded malocclusion (Fig 3). She had a baby, 4 months of age, but was not breast-feeding. She had not had the opportunity to have orthodontic treatment when she was younger, and hinted that she was hoping to have orthodontic work completed before planning for a second child. The estimated length of treatment time using conventional orthodontic techniques was 2 years. When presented with the option of having her teeth straightened in one-quarter to one-third the time needed for conventional orthodontics, she readily accepted. She did not object to the inclusion of a periodontal plastic surgical procedure with resorbable grafting materials. She had a healthy periodontal status. Radiographically, there did not appear to be any significant bone loss and, clinically, there were no probing depths greater than 3 mm. There was an adequate zone of attachment and no gingival recession. With the exception of the maxillary left first molar, which had been treated endodontically and then posted and crowned, all of the patient's teeth registered vital to ice. The orthodontic treatment plan included maxillary and mandibular braces and called for expansion and rounding of the arches to accomplish the decrowding. The patient requested "clear braces" in her maxillary anterior area, due to esthetic considerations.

CLINICAL PROCEDURE

Both maxillary and mandibular bands and brackets were placed during the week preceding the AOO surgery. In addition, maxillary and mandibular nickel-titanium (NiTi) wires were fully engaged from second molar to second molar. Care was taken to remove interproximal bonding flash, which could make surgical suturing difficult.

The surgery was performed on both the maxillary and mandibular arches at the same surgical appointment, under intravenous sedation and local anesthesia. Labial and lingual sulcular incisions were made using a 12 B Bard-Parker blade (BD, Franklin Lakes, NJ, USA) around all of the remaining maxillary and mandibular teeth, except lingually between the maxillary central incisors. No vertical releasing incisions were used. As much as possible of the interdental papillae were reflected with the full-thickness labial and lingual flaps, except lingually between the maxillary central incisors, where the interdental papilla was not reflected. Any pieces of the interdental papillae not reflected with the flaps were left in place and not removed. The flaps were reflected beyond the apices of the teeth, with care taken not to disturb any of the neurovascular bundles exiting the bone and the genioglossus attachment.

At the instruction of the orthodontist, selective partial decorticating (bone activation) was performed on the labial and lingual aspects of the maxillary and

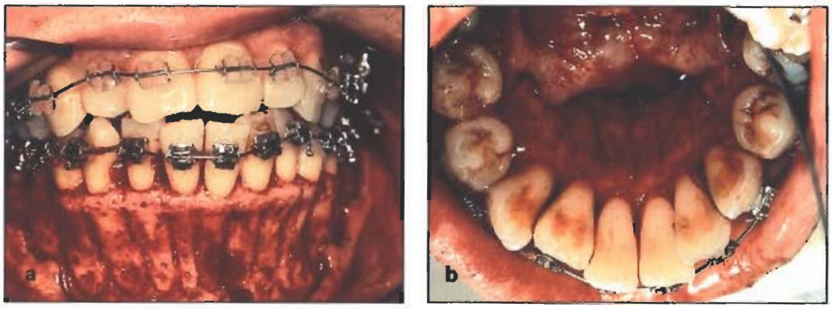

Fig 4 Mandibular anterior/premolar area showing the combination of circumscribing corticotomy cuts and small corticotomy perforations. **(a)** Anterior and **(b)** lingual views.

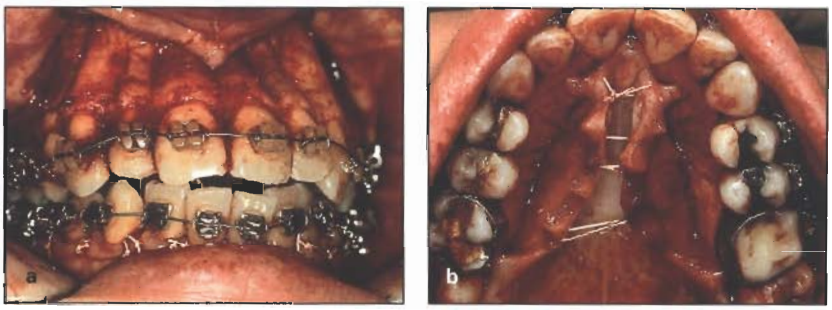

Fig 5 Maxillary anterior/premolar area showing the combination of circumscribing corticotomy cuts and small corticotomy perforations. **(a)** Anterior view and **(b)** palatal view, in which temporary suturing for improved surgical visualization can be seen between the palatal flaps.

mandibular anterior teeth and premolars (Figs 4 and 5). These teeth would be undergoing the major movement and the molars would serve mostly as anchorage units.

The limited labial and lingual decorticating was accomplished with circumscribing corticotomy cuts outlining the roots of the teeth and small round corticotomy perforations where possible. The corticotomy cuts and perforations were made with a #2 long-shank round bur in a high-speed handpiece with copious water irrigation and extended only barely into the medullary bone. The interradicular vertical corticotomy cuts began a couple of millimeters below the alveolar crest and extended 2 to 3 mm beyond the apices of the teeth, where they were connected with a scalloped horizontal connecting corticotomy cut. The additional corticotomy perforations were made where it was possible to attain additional bleeding points. No bony luxating was performed following the partial decorticating.

An established resorbable grafting mixture for osseous augmentation consisting of approximately equal amounts by volume of demineralized freeze-dried bone allograft (DFDBA) and bovine bone was used (personal communications with Dr Roland Meffert). The DFDBA (Musculoskeletal Transplant Foundation, Edison, NJ, USA) and bovine bone (Bio-Oss 0.25 to 1.0 mm; Osteohealth, Shirley, NY, USA) were mixed dry, and then wet with a clindamycin phosphate/sterile water solution (approximately 10 mg/mL) just prior to placement. The wet grafting mixture was then spread over the partially decorticated bone, both labially and lingually (Figs 6 and 7). On average, the layer of grafting material was between 2 and 3 mm thick. The full thickness flaps were returned to their original position and sutured into place with interrupted loop 4/0 Gore-Tex suture material (W.L. Gore, Flagstaff, AZ, USA). Care was taken to properly reposition the interdental papillae (Fig 8). In general, one interproximal interrupted loop suture was found to be adequate in the posterior areas; however, two of these sutures, one on the mesial and one on the distal of each interdental papilla, were typically required in the anterior area.

Postsurgically, the patient was prescribed Pen VK 250 mg, 4 times per day for 10 days. For discomfort, she was prescribed both Hydrocodone APAP 7.5/650 mg and Naproxen Sodium 550 mg. She was asked to discontinue the Naproxen Sodium as soon as possible. After the first week postsurgery, she was asked not to take any nonsteroid anti-inflammatory drugs until the orthodontic work was completed.

Periosteal releasing incisions were not required for passive flap adaptation in this case. Occasionally, periosteal releasing incisions are needed, especially if a thick layer of grafting material is deemed appropriate. Suture removal was performed 2 weeks postsurgery.

The patient's teeth were cleaned about 1 month following the surgery and the importance of good oral hygiene was reinforced. The patient was briefly checked on a couple of additional occasions prior to the completion of the orthodontic work, and on each occasion her oral hygiene was found to be adequate.

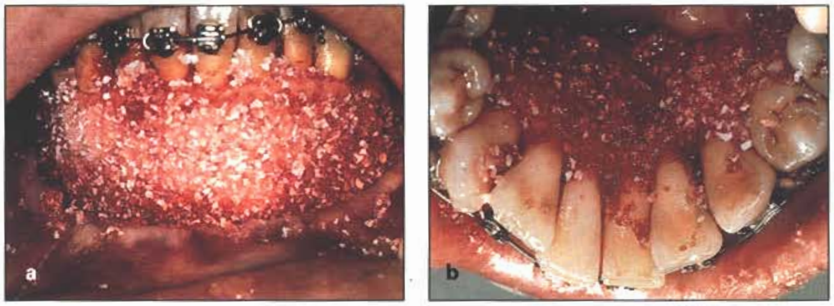

Fig 6 Mandibular anterior/premolar area showing the grafting mixture spread over the partially decorticated bone. **(a)** Anterior and **(b)** lingual views.

Fig 7 Maxillary anterior/premolar area showing the grafting mixture spread over the partially decorticated bone. **(a)** Anterior and **(b)** palatal views.

Fig 8 Anterior view following the completion of the suturing.

The first orthodontic adjustment was performed approximately 2 weeks following surgery. Thereafter, the orthodontic adjustments were made at about 2-week intervals until the treatment was completed. Comparable tooth movements are accomplished in 2 weeks with the AOO procedure, as compared to conventional orthodontics in 6- to 8-week intervals.

Maxillary and mandibular clear overlay retainers were constructed and placed immediately following the removal of the orthodontic appliances. A normal instruction regimen was given for the postorthodontic treatment retainer wear.

The total treatment time from bracketing to debracketing was exactly 6 months. Figure 9 shows the completed case on the day of debracketing. This orthodontic treatment required 12 adjustment appointments and there were no appliance breakages.

The posttreatment evaluation revealed no probing depths greater than 3 mm, good preservation of the interdental papillae, maintenance of an adequate zone of gingival attachment with no gingival recession, no loss of tooth vitality, no clinically significant reduction in the radiographic height of the crestal bone, and no radiographic evidence of any clinically significant apical root resorption. The pretreatment radiographs are shown in Fig 10 and the posttreatment radiographs are shown in Fig 11. The patient stated that she was pleased with her esthetic result. Approximately 1 year following debracketing, the patient delivered her second healthy child.

DISCUSSION

Correction of a Class I moderately crowded case utilizing a new orthodontic treatment modality has been presented. This new treatment (the AOO procedure) combines the advantages of both corticotomy-facilitated orthodontics and periodontal alveolar augmentation.[1] The periodontal plastic surgery portion of the

Fig 9 Intraoral views of the patient on the day her teeth were debracketed. **(a)** Anterior and **(b)** left lateral views.

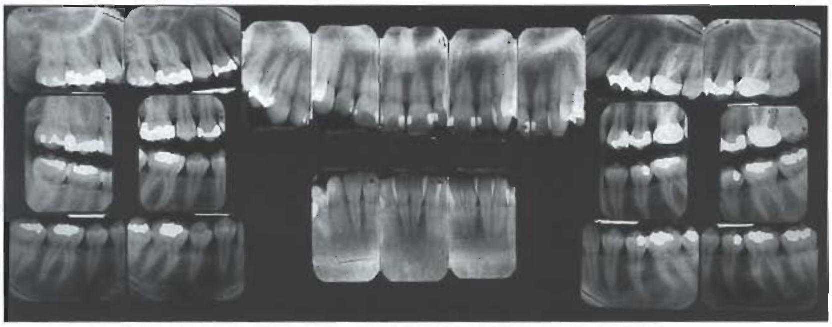

Fig 10 Pretreatment radiographs.

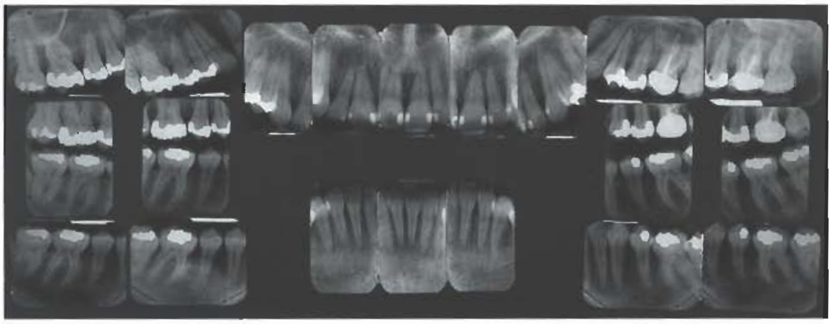

Fig 11 Posttreatment radiographs.

AOO procedure needs to be performed in a disease-free environment. The alveolar augmentation can provide the patient with a more structurally intact periodontium at the completion of the orthodontic work.

The patient presented in this report was not surgically re-entered. Several other cases, however, in which a mixture of DFDBA and bovine bone were used as the grafting mixture, have been re-entered and this mixture has been found to be consistently converted to natural bone. The histologic findings from one such case are presented. The bone biopsy in this case was taken from the labial of the mandibular right canine at approximately 9 months 2 weeks postsurgery. This patient was a female, 38 years of age, and the total orthodontic treatment time was 4 months 2 weeks. Both microscopic and polarized light were used in the histologic evaluation. Photomicrographs of the core sample of bone from the facial aspect of the mandibular right canine, approximately 3.7 mm thick from surface cortex to lamina dura, are shown (Figs 12 to 14). The sample fortuitously includes a fragment of cementum accidentally chipped away during the biopsy procedure. The section shows cortical bone from the cortex to the lamina dura with only small marrow spaces present. The lamina dura appears somewhat immature and there is still occasional new bone formation. A few elongated spaces are filled with a somewhat grainy bluish/gray foreign material consistent with the bovine augmentation material (Osteograf N/300; Ceramed, Lakewood, CO, USA). This material has bone laid on its surface with some abundance and is sometimes surrounded by the only remaining hematopoietic tissue. The bone shows no missing osteocytes, appears viable, and there are no apparent remnants of the freeze-dried bone. Bone immaturity is demonstrated by a somewhat irregular pattern

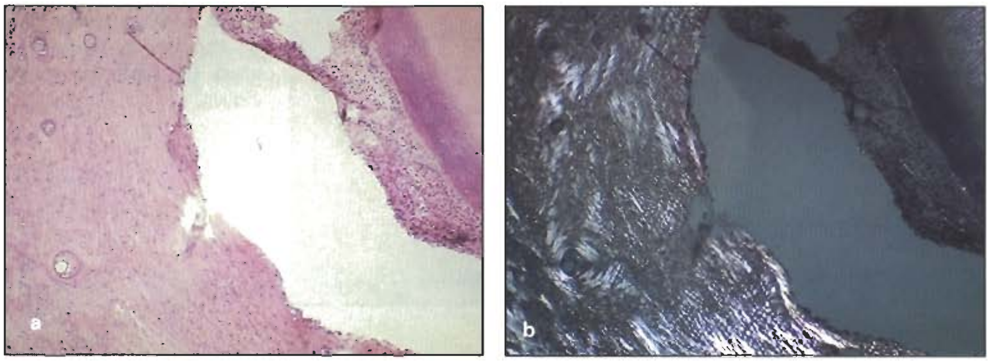

Fig 12 **(a)** Bone biopsy core taken from the labial aspect of the mandibular right canine of another patient who underwent the same procedure, showing the dentin, cementum, PDL, and lamina dura. The tears are processing artifacts (original magnification × 100; hematoxylin-eosin stain). **(b)** Same area shown in (a), but under polarized light microscopy. Note that the lamina dura appears somewhat immature and there is still occasional new bone formation (original magnification × 100; hematoxylin-eosin stain).

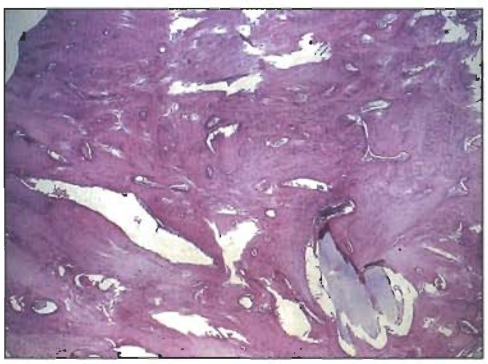

Fig 13 Photomicrograph showing the center of the bone biopsy core taken from the labial aspect of the same mandibular right canine in Fig 12. The tears are processing artifacts. Note, a few pieces of bovine bone in the lower right area that are still not completely resorbed (original magnification × 40; hematoxylin-eosin stain).

Fig 14 Photomicrograph showing the cortical surface of the bone biopsy core taken from the labial aspect of the same mandibular right canine in Figs 12 and 13 (original magnification × 200; hematoxylin-eosin stain).

with the use of the polarizing light, but notice that portions of the new bone show the regular, laminar pattern of mature bone. There seems to be good maturation of the outer cortex to the inner lamina dura, and most of the more active newly forming bone is seen closer to the tooth surface than the outer cortex. This augmentation procedure is safe and effective and can be used to cover pre-existing bony fenestrations over the root prominences.[1] In certain situations, the additional alveolar bone can also provide improved lip posture. In an evaluation of this new orthodontic method, Hajji demonstrated increased thickness of alveolar bone at the cephalometric landmark B point in the AOO group, when compared to nonsurgery orthodontic therapies.[2] Machado also showed increased maxillary anterior alveolar bone thickness at the level of cephalometric point A in a study comparing nonextraction orthodontic therapy with AOO and without corticotomy.[10]

In 1984, Goldie and King reported an increased rate of tooth movement and decreased root resorption in lactating female rats fed a calcium-deficient diet.[11] They surmised that the resulting increase in parathyroid hormone secretion led to increased osteoclasis, an observation later confirmed by Horowitz et al.[12] The enhanced tooth movement and decreased area of root surface resorption were attributed to the increase in bone metabolism and decrease in bone density. In the 1980s, orthopedist Harold Frost described the physiologic events following surgical wounding of bone, which he termed the regional acceleratory phenomenon (RAP).[13,14] The initial dominating features of RAP involve accelerated bone turnover and decreased regional bone densities. Surgical wounding of the cortical bone produces a transient burst of localized hard and soft tissue remodeling that potentiates tissue reorganization and healing.[15] In 1994, Yaffe et al reported on RAP occurring in the mandibular bone in rats.[16] It was suggested that in humans RAP would commence a few days after surgery, peak between 1 and 2 months, and take from 6 to 24 months to resolve completely. They attributed the initial increase in bone porosity to increased osteoclastic activity. They speculated that the increased mobility of the teeth following periodontal surgery might be due to the early demineralization phase of RAP. This was consistent with an earlier report by Pfeiffer, describing increased osteoclastic activity along the PDL surface after surgery.[17] Moreover, Hajji was able to show a 3-fold increase in the rate of decrowding in corticotomy-facilitated orthodontic treatment.[2] Radiographic evaluation of periapical radiographs and findings of decreased radiopacity postcorticotomy add to the indirect evidence that RAP osteopenia, ie, calcium depletion and diminished bone density, creates the environment that facilitates rapid tooth movement.

The orthodontic appointments for decrowding cases utilizing the AOO procedure consist of normal wire changes, elastic usage, and orthodontic mechanics, only at a greatly accelerated rate as compared to conventional orthodontic treatment. In decrowding cases, excessive orthodontic forces are not used and are not needed to achieve these accelerated rates of tooth movement. The orthodontic clinician must be aware, however, that dental anchorage changes as a consequence of the alveolar osteopenia. The teeth located between the labial-lingual cortical plates that have undergone corticotomy will move more rapidly than teeth distant from the surgery site.

No clinically significant apical root resorption was noted in the case that has been presented. This is consistent with the findings of Machado in master's thesis research on apical root resorption of the maxillary central incisors under conditions of orthodontic tooth movement with and without the corticotomy facilitation.[10] The average age was 24.8 years for the corticotomy-facilitated group and 19.6 years for the conventional group. Machado found significantly less postorthodontic treatment root resorption (1.1 mm) in corticotomy-facilitated nonextraction therapy.

For tooth movement to occur in conventional orthodontic decrowding, it is essential that the lamina dura adjacent to the PDL undergo osteoclasis on the "pressure" side of the root. If hyalinization necrosis (a dead zone) occurs, osteoclastic activity ceases in the damaged area of the PDL. Frontal movement stops for 3 to 5 weeks while the damaged tissue is removed. Rygh and Brudvik have cited increasing evidence suggesting an association between the removal of the necrotic hyalinized PDL tissue and orthodontic root resorption.[18]

With increasing age, the cellular activity and vascularity decrease in the PDL and surrounding bone. Brezniak and Wasserstein have speculated that this decrease in PDL and bone vitality are reflected in a higher susceptibility to root resorption in adults.[19] It is possible that RAP osteopenia, with its increased osteoclastic activity and decreased bone density, lessens the likelihood of hyalinization necrosis and root resorption. If this is the situation, one would anticipate seeing diminished root resorption, as in the case that has been presented.

There has been little, if any, clinically noticeable relapse 1.5 years after debracketing. This is consistent with Fulk's findings (master's thesis research) in an assessment of mandibular dental arch stability of orthodontic treatment results, when comparing nonextraction orthodontics with and without alveolar corticotomy.[20] Although there were no significant differences between the two groups with respect to the 12 variables that were measured, there were differences in the kind of change that occurred during retention. There was relapse in the mandibular incisor irregularity index and the cephalometric angle SNB in the nonsurgery group, but not in the corticotomy-facilitated group. The alveolar augmentation may have provided additional bony support, resulting in greater resistance to relapse.

CONCLUSION

A case report has been presented that demonstrates the use of the AOO procedure for rapid orthodontic decrowding.[1] This new procedure combines the advantages of corticotomy-facilitated orthodontics and periodontal alveolar augmentation.

In decrowding cases such as the case described, conventional orthodontic forces are sufficient to achieve the rapid tooth movement. This decrowding can be accomplished in one-third the time of conventional orthodontics.[2] Delivery of excessive clinical orthodontic forces is not required. The indirect evidence would suggest that the RAP osteopenic environment, with increased osteoclastic activity and decreased bone density, facilitates the rapid tooth movement and significant reduction in root resorption.[10]

The periodontal alveolar augmentation can provide an improvement in the structural integrity of the periodontium.[1] Hajji[2] has shown an increase in the thickness of the alveolar bone at the cephalometric landmark B point, and Machado[10] has shown the same for the cephalometric point A area. This increase in the alveolar bone thickness can, in certain situations, provide a degree of improvement in lip posture.

The AOO procedure provides a safe alternative for those patients with moderate crowding who desire the benefits of orthodontic treatment in a relatively short period of time.

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